Functions of Sustainable Facade
Façade based upon outdoor climate and indoor comfort

Visual comfort inside the building
Enhanced sun protection - Lower Heat Gains - Lower Cooling Load – Lower Energy Consumption

American Institute of Indian Studies, Gurgaon

Noise control
Resilient to Climate Hazards

Sustainable Architectural Facades

Architectural design that provides comfort to occupants using nature’s resources and with minimal impact on the environment.
Green Building Initiatives for Climate Resilient Affordable Housing

Project for HUDCO

Good Earth Malahar, Bangalore

Façade needs to respond to local context, cultural values, tradition
Case Study
V B H C Vaibhava
Architect: InFORM

<table>
<thead>
<tr>
<th>Climate (as per NBC)</th>
<th>Warm-Humid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architect</td>
<td>Inform</td>
</tr>
<tr>
<td>FSI</td>
<td>1.3</td>
</tr>
<tr>
<td>Density</td>
<td>180 families/Hectare</td>
</tr>
<tr>
<td>Construction Period</td>
<td>18 Months</td>
</tr>
<tr>
<td>Level of Mechanisation</td>
<td>High</td>
</tr>
<tr>
<td>Skilled Labour</td>
<td>High</td>
</tr>
<tr>
<td>Total Cost of Construction</td>
<td>~ Rs. 2400/Sft</td>
</tr>
<tr>
<td>Distance From City</td>
<td>~ 50 KM</td>
</tr>
</tbody>
</table>

Aura – Mahindra Life spaces, Gurgaon

Respond to Urban Planning
Case Study
Passive Solar houses - Ladakh

Location
Located to North of Leh
160 Km from Centre of City

Ursi village

3 Types of PSH Design

Direct gain (DG)

Construction cost = INR 958/m2 of wall area
Solar Wall (SW)

Construction cost = INR 1596/m² of wall area

Façade design and Urban Heat Island Effect
Sustainable Building facades: Minimizing urban heat island effect and imperviousness factor

Introduction

Hypothesis

Field Study

Simulation

Conclusion

Literature

Base Case  Reflective Roof  Green roof

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Commercial Office</th>
<th>Commercial Office</th>
<th>Commercial Office</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone Area</td>
<td>40000Sft</td>
<td>40000Sft</td>
<td>40000Sft</td>
</tr>
<tr>
<td>Height</td>
<td>3 m</td>
<td>3 m</td>
<td>3 m</td>
</tr>
<tr>
<td>Lighting power density</td>
<td>1.4 W /ft²</td>
<td>1.4 W /ft²</td>
<td>1.4 W /ft²</td>
</tr>
<tr>
<td>Equipment power density</td>
<td>0.75 W /ft²</td>
<td>0.75 W /ft²</td>
<td>0.75 W /ft²</td>
</tr>
<tr>
<td>Occupants</td>
<td>275 ft² / person</td>
<td>275 ft² / person</td>
<td>275 ft² / person</td>
</tr>
<tr>
<td>Occupancy Schedule</td>
<td>8 hours, 5 days a week</td>
<td>8 hours, 5 days a week</td>
<td>8 hours, 5 days a week</td>
</tr>
<tr>
<td>External wall</td>
<td>Uninsulated 230mm Brick Wall</td>
<td>Uninsulated 230mm Brick Wall</td>
<td>Green Roof with U-value 0.23 W/m²</td>
</tr>
<tr>
<td>External Roof</td>
<td>Uninsulated 150mm RCC Roof</td>
<td>Uninsulated 150mm RCC Roof with reflective coat (albedo 0.9)</td>
<td>Green Roof with U-value 0.23 W/m²</td>
</tr>
<tr>
<td>Glazing Specification</td>
<td>6mm clear glass</td>
<td>6mm clear glass</td>
<td>6mm clear glass</td>
</tr>
</tbody>
</table>

Cooling load reduction due to improved micro climate

Hourly cooling load variation of a typical commercial space with different micro climates

Peak cooling load of a typical commercial space with different micro climates
Façade to compliment Heating/cooling strategies

Low energy cooling- Thermal Storage system

Natural Ventilation and cooling

conventional currents rising up due to heating of air in cavity wall (low pressure zone)

heat from solar rays falling on the south west wall (black kudappah wall)
Wind tower

- Daytime- outside air enters through the openings, gets cooled, becomes heavier, sinks down and into the rooms and vented out through the windows.

- Nighttime-the tower warms up, draws in cooling air through the windows and creates upward draught.

Solar chimney

- Uses stack effect, but chimney deliberately heated by solar radiation.
- Space detached from the main building.
- Advisable for regions with low wind speed.
- Could be roof or wall integrated.
- Could be coupled with other natural conditioning systems.
Aesthetic Aspiration - Branding

Ashok Leyland Office (West Façade), Chennai
Modern buildings
Modern buildings

Modern buildings
Examples from Europe

Application of bioclimatic architectural principles and passive feature examples could be learnt both from National as well as International buildings.

Universally applicable principles of natural daylight and passive cooling/heating

BRE Office Building I Watford (UK). I Feilden Clegg Architects

- British Research Establishment office
- L-shaped building
- 2000 m² total floor area
- North South facing
- Natural ventilation and daylight strategy through:-
  - Stack towers
  - Wave shaped ceiling slabs
- Automatic & manual control shading devices
- Natural daylight
- Exposed concrete ceiling for night ventilation
- Energy consumption of 144 kWh/sq m/annum
Queens Building, De Montford University | Leicester (UK). | Short Ford & Associates

**Houses school of Engineering & Manufacture.**
- Environmental aspects of design through natural ventilation and daylighting
- Double height Mechanical Lab
- Central deep 4 storied section for general labs.
- U shaped 4 storied narrow wings for electrical labs.
- Ventilation through ridge vents. Cool fresh air is introduced at low level. High illuminance achieved through roof lights.


**Sainsbury Supermarket located in Greenwich, London**
- Sales floor background lighting turned off during the day, display lighting at product level.
- Double glazed north lights.
- Passive ventilation roof vent dampers.
- Light colored floor and ceiling to enhance internal reflectance.
Building Envelope

- Windows / Fenestration / Aperture
- Walls / Opaque surfaces
- Roof

Process to achieve Efficient Façade Design

- Passive/low energy Design to reduce the demand
- Energy Efficient lighting and AC
- Controls to reduce the energy
- Integration of Renewable energy
Orientation

- Daylight availability
- Sun path diagram, to keep away the sun and reduce external heat gains

Climate Analysis

Hourly weather file processing from daily data acquired from meteorology department

Psychrometric Chart

Location: Bhadrachalam, IND
Frequency: 1st January to 31st December
Weekday Times: 00:00-24:00 Hrs
Weekend Times: 00:00-24:00 Hrs
Barometric Pressure: 101.36 kPa

SELECTED DESIGN TECHNIQUES:
1. exposed mass + night-purge ventilation
2. natural ventilation

Blue dots show outdoor climate of Bhadrachalam
Thermal comfort band and extended adaptive comfort bands after integrating passive strategies
ITC Bhadrachalam – Residential Township

- Solar irradiation analysis – high rise dense development

- Increase in daylight and decrease in shading factor especially in rooms facing inner courtyards - as we go up in dense developments

- No additional shading for lower floors and an optimized shading for upper floors is recommended to maintain uniform thermal and visual comfort conditions across the floors

Solar analysis for High-rise structures

Daylight availability across the floors

Schematic section showing shading design to respond to solar exposure

<table>
<thead>
<tr>
<th>Floor Level</th>
<th>Average DF</th>
<th>Shading Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Floor</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Fifth Floor</td>
<td>1.5</td>
<td>0.83</td>
</tr>
<tr>
<td>Ninth Floor</td>
<td>3.5</td>
<td>0.56</td>
</tr>
</tbody>
</table>

- Increase in daylight and decrease in shading factor especially in rooms facing inner courtyards - as we go up in dense developments

- No additional shading for lower floors and an optimized shading for upper floors is recommended to maintain uniform thermal and visual comfort conditions across the floors
Higher wind speeds for better comfort in outdoor, semi outdoor and courtyard spaces and by adding a stilt, bridges and intermediate courts and landscape elements.

Outdoor Wind Flow analysis for High-rise structures

Wind speeds (m/s) at 1.5m from Ground

Before

After

- Intermediate Courts
- Bridges

Conceptual Sketch and actual CFD model of Window System
Proposed for Non Ventilated Spaces
## Building envelope optimization for Air conditioned and Non Air conditioned spaces

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Roof U-Value W/m2K</th>
<th>Wall U-Value W/m2K</th>
<th>Glazing View Window U-Value W/m2K</th>
<th>AC Spaces</th>
<th>Reduction in TR Load (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Base Case</td>
<td>2.49</td>
<td>3.17</td>
<td>6.17</td>
<td>0.815</td>
<td>0.88</td>
</tr>
<tr>
<td>2 ECBC Roof Case_Over deck</td>
<td>0.36</td>
<td>3.17</td>
<td>6.17</td>
<td>0.815</td>
<td>0.88</td>
</tr>
<tr>
<td>3 ECBC Roof Case_Under deck</td>
<td>0.37</td>
<td>3.17</td>
<td>6.17</td>
<td>0.815</td>
<td>0.88</td>
</tr>
<tr>
<td>4 Glazing optimised Case</td>
<td>2.49</td>
<td>3.17</td>
<td>1.59</td>
<td>0.28</td>
<td>0.4</td>
</tr>
<tr>
<td>5 Cumulative 1(Over Deck)</td>
<td>0.36</td>
<td>3.17</td>
<td>1.59</td>
<td>0.28</td>
<td>0.4</td>
</tr>
<tr>
<td>6 Cumulative2 (Under Deck)</td>
<td>0.37</td>
<td>3.17</td>
<td>1.59</td>
<td>0.28</td>
<td>0.4</td>
</tr>
</tbody>
</table>

### Daylight harvesting: BSBE Building, Kanpur

![Image of daylight harvesting](image_url)
Daylight

THE BUILDING IS DESIGNED TO DEFLECT THE FOUL BREEZE AND USE THE PRESSURE TO PULL IN FRESH AIR FROM THE NORTH EAST.

Renewable Energy Integration in Site Planning
Building Integrated Photo Voltaics (BIPV)
Efficient façade design

Light shelves allow daylight to penetrate deeper into the buildings

Mysore SDB 5 building with above strategies  Bright day light without glare

Source: Infosys
Efficient building envelope

SDB-2 & 3, Infosys Hyderabad campus

CESE building, IIT Kanpur
CESE building, IIT Kanpur

Suzlon OneEarth, Pune
GRIHA 5 star
EPI (final achieved) = 33 kWh/sqm/annum
VVIP Circuit House, Pune
General Information

Site Area: Approx 9584.24m²
Built up Area: 4886.90 m²
Air-conditioned Area: 2629.93 m²
Non Air-conditioned Area: 2256.97 m²
Energy Performance Index (EPI): 89.16 KWh/m²/year
Renewable Energy: Rated capacity of solar PV installed on site is 22 KW
GRIHA provisional rating: 5 Stars
Year of completion: 2014 - 15

More than 80% of the regularly occupied spaces receive optimum daylight. The building is optimally oriented and façade is designed such that the heat gain is minimized and daylight is maximized.
Govardhan Ecovillage, Thane

Location: Galtare, Wada, Thane, Maharashtra - 421303
Site Area: 70 acres
Built up Area: 2400.65 m2
Non Air-conditioned Area: 2400.65 m2
Energy Consumption Reduction: 57% reduction compared to GRIHA benchmark
EPI: 42 KWh/ m2/year
Renewable Energy: 30KWp
GRIHA provisional rating: 5 Stars
Year of completion: ...2012...
- Optimum window openings
- Light floor for light diffusion
- Soft landscape outside giving no reflected glare
- Shaded walls and openings

High Performance Commercial Buildings in India Studies under APP

Impact of Low energy strategy (LES) on Energy performance Index (EPI) kWh/m²/year
- Conventional case: 161 kWh/m²/year
- Impact of Low energy strategy (LES): 125 kWh/m²/year
- Impact of ECBC features: 73 kWh/m²/year

High Performance Building case: 59 kWh/m²/year
Façade retrofits

- New buildings absorb 5 times less heat compared to existing buildings
- Opportunity to reduce heat gain in existing buildings through glazing, shading and insulation

Source: Infosys

Thank You

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